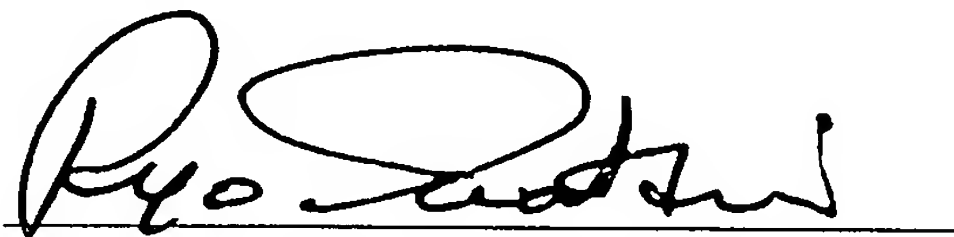# VERIFICATION OF TRANSLATION

I, Ryo Iwatani, of 15-15, Kamikotoen 3-chome, Nishinomiya-shi, HYOGO 662-0813 JAPAN, state the following:

I am fluent in both the English and Japanese languages and capable of translating documents from one into the other of these languages.

The attached document is a true and accurate English translation to the best of my knowledge and belief of the Test Method 8.11.A of JIS L1013 (1999).

I state that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true.

Signature: _____
                     Ryo IWATANI

Date: _____May 23, 2003_____

8.11 Stretchability

Method A (Every yarn measurement) Fix the upper end of the test specimen with a clamp, hang it by applying 0.176mN x indicated tex as the initial load* and 30 seconds later, mark the point accurately 20 cm (a) distant from the upper clamp. Thereafter, apply the load* that is 8.82mN x indicated tex, and 30 seconds later, measure the length (b) of the test specimen. After removing the load, leave the specimen still for 2 minutes, apply the initial load again, and, 30 seconds later, measure the length (c) of the test specimen. Calculate the elongation percentage (%) of and the elastic modulus (%) of stretchability according to the following formula. Repeat this test 20 times, and express the average down to one place of decimal.

$$\text{Elongation percentage (\%) of stretchability} = \frac{b-a}{a} \text{ x } 100$$

$$\text{Elastic modulus (\%) of stretchability} = \frac{b-c}{b-a} \text{ x } 100$$

Remark (*): If this specified initial load is inappropriate, alter it to other suitable load, provided that is shall be appended in the test report.
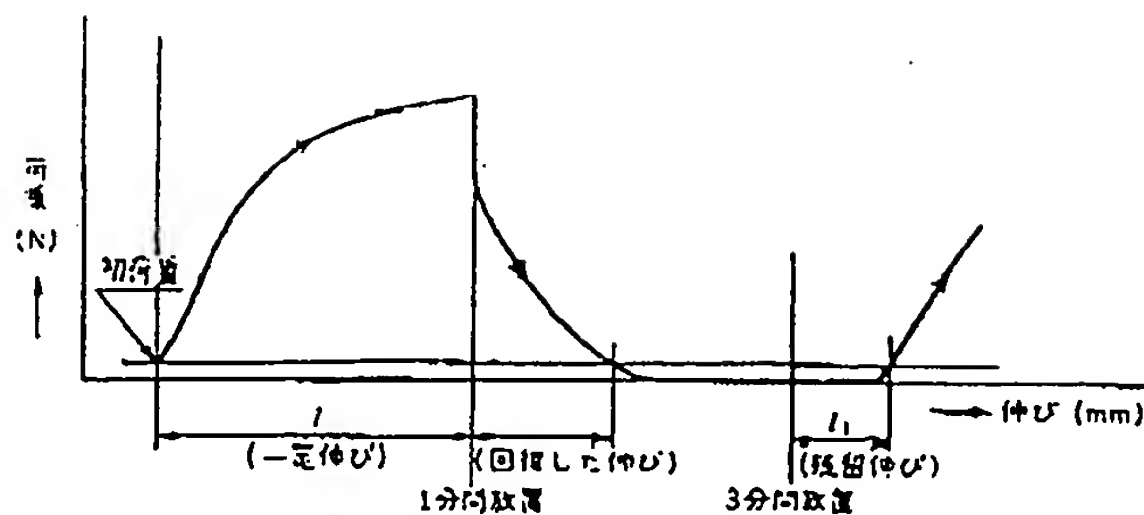
図6　荷重-伸長曲線

備考1.　試験の種類及び試験条件（つかみ間隔，引張速度，伸長率）を記録に付記する。
　　2.　記録紙の荷重範囲は，一定伸びのときの荷重が，少なくとも全目盛の50 %になることが望ましい。
　　3.　記録紙の速度は，一定伸びが記録紙上で少なくとも5 cmに相当するように決める。
　　4.　A法はすべての繊維に適用し，B法は主として合成繊維に適用する。

8.10　初期引張抵抗度　初期引張抵抗度は，試料を8.5.1と同じ方法で試験を行って，図7のように荷重-伸長曲線を描き，この図から原点の近くで伸長変化に対する荷重変化の最大点A（接線角の最大点）を求め，次の式によって初期引張抵抗度（N/tex）を算出し，10回の平均値をJIS Z 8401によって整数位に丸める。

$$T_{ri}=\frac{P}{\frac{l'}{l}\times F_0}$$

　　　ここに，　T_{ri}：初期引張抵抗度（N/tex）
　　　　　　P：接線角の最大点Aにおける荷重（N）
　　　　　　F_0：正帝繊度（tex）
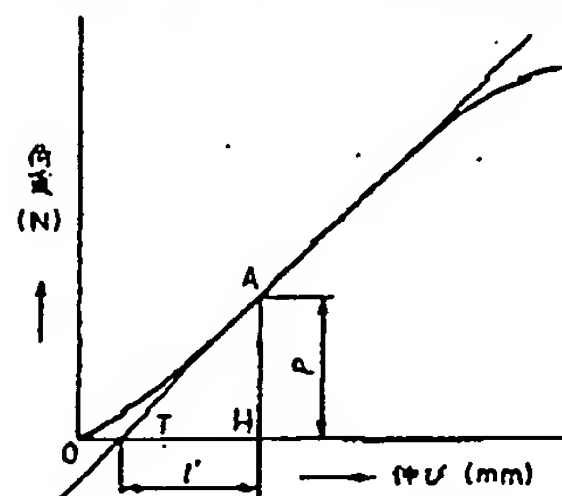　　　　　　l：試験長（mm）
　　　　　　l'：THの長さ（mm）
　　　　　　　（Hは垂線の足，Tは接線の横軸との交点）

図7　荷重-伸長曲線

備考1.　測定誤差を少なくするために，初期の荷重-伸長曲線のA点における接線が，伸び軸に対して約45°になるようにチャートスピードを調節するのがよい。
　　2.　初期引張抵抗度と見掛ヤング率との関係は，次の式のとおりである。

$$Y_m=1000\times\rho\times T_{ri}$$

　　　ここに，　Y_m：見掛ヤング率（N/mm²）
　　　　　　ρ：繊維の密度（g/cm³）
　　　　　　T_{ri}：初期引張抵抗度（N/tex）

　　3.　試験機は原則として定速伸長形引張試験機を用い，引張条件を記録に付記する。ただし，その他の試験機を用いた場合は，試験機の種類及び引張条件を記録に付記する。

8.11　伸縮性
a)　A法（1本ずつ測定する場合）　試料の上端をクランプで固定し，0.176 mN×表示テックス数の荷重[10]をかけて垂下し，30秒後上部クランプから正しく20 cm（a）を測って印を付け，次に8.82 mN×表示テックス数の荷重をかけて30秒後の試料の長さ（b）を測り，除重後，2分間放置して再び0.176 mN×表示テックス数の荷重を[10]かけて30秒後の試料の長さ（c）を測り，次の式によって伸縮伸長率（%）及び伸縮弾性率（%）を算出する。試験回数は20回とし，その平均値をJIS Z 8401によって小数点以下1けたに丸める。

$$S_e=\frac{b-a}{a}\times100$$

$$E = \frac{b-c}{b-a} \times 100$$

ここに， S_t：伸縮伸長率 (%)

E：伸縮弾性率 (%)

a：0.176 mN×表示テックス数の荷重をかけて30秒後に，試料に付けた印の，上部クランプからの距離 (20 cm)

b：8.82 mN×表示テックス数の荷重をかけて30秒後の試料の長さ (cm)

c：0.176 mN×表示テックス数の荷重をかけて30秒後の試料の長さ (cm)

注(10) 荷重が不適切な場合は適切な荷重を用い，それを記録に付記する。

b) B法 (10本束ねて測定する場合) 試料を図8 a)のように，試料に損傷を与えないような棒にかけて輪にしたものを5個作り，それぞれ8.82 mN×2×表示テックス数の荷重をかける。

この5個の試料を図8 b)のようにひとまとめにして，約50 cmの間隔を置いて上下を綿糸でしっかり結んだ後，直ちに荷重を除く。

このようにして作った10本1束の試料を図9のように0.176 mN×10×表示テックス数の荷重(10)をかけた状態で，試験長が約20 cmになるように試料上部をクランプで固定し，30秒後の試料の長さ (a) を正しく測る。
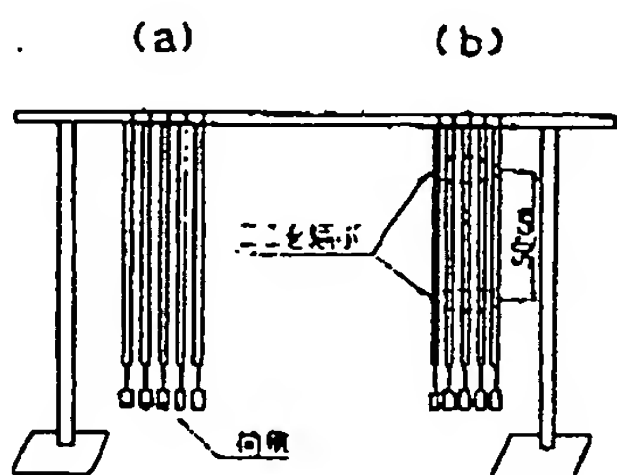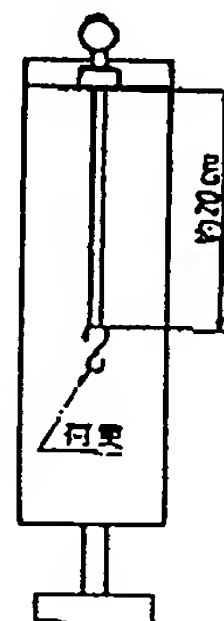

図8　　　　　　　　　図9

次に，8.82 mN×10×表示テックス数の荷重をかけて30秒後の試料の長さ (b) を測り，除重後2分間放置して再び荷重(10)をかけて30秒後の試料の長さ (c) を測り，A法 (1本ずつ測定する場合) と同様の式によって伸縮伸長率 (%) 及び伸縮弾性率 (%) を算出する。試験回数は10回とし，その平均値をJIS Z 8401によって小数点以下1けたに丸める。

c) C法 (簡便法) 適切なテンション調整装置をもつ検尺機を用い，巻き数10回のかせ(11)を作り，0.176 mN×20×表示テックス数の荷重(10)をかけ，30秒後の長さ (a) を測る。次に8.82 mN×20×表示テックス数の荷重をかけて30秒後の長さ (b) を測り，荷重を除いた後2分間放置して再び0.176 mN×表示テックス数の荷重(10)をかけて30秒後の試料の長さ (c) を測り，A法 (1本ずつ測定する場合) と同様の式によって伸縮伸長率 (%) 及び伸縮弾性率 (%) を算出する。試験回数は10回とし，その平均値をJIS Z 8401によって小数点以下1けたに丸める。

注(11) 試料のかせの調整で，湿熱処理を行う場合は，かせが乱れないように2か所を束ねてくくり，8の字状にして二つに折り重ねて輪にすることを2回繰り返し，ガーゼに包んだまま処理する。

備考　合成繊維の伸縮性かさ高加工糸に適用する。

8.12 伸縮復元率　0.176 mN×表示テックス数の荷重をかけてかせ長約40 cm，巻き数10回の小かせを作る。この試料を図10のように，0.176 mN×20×表示テックス数の荷重(10)(12)と，更に8.82 mN×20×表示テックス数の荷重(12)を加えて温度20±2 ℃(13)の水中(14)に2分間浸せきした後，かせ長を測り，直ちに8.82 mN×20×表示テックス数の荷重を除いて2分間放置後，再びかせ長を測り，次の式によって伸縮復元率 (%) を算出する。試験回数は5回とし，その平均値をJIS Z 8401によって小数点以下1けたに丸める。

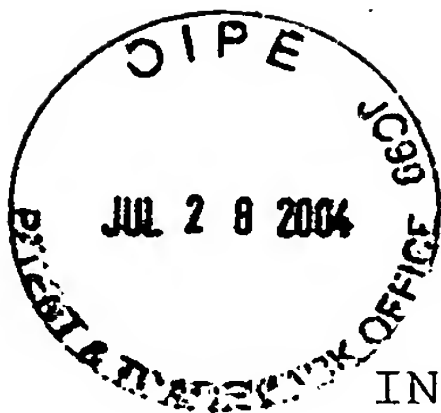$$E_r = \frac{a-b}{a} \times 100$$

ここに，E_r：伸縮復元率 (%)

a：0.176 mN×20×表示テックス数の荷重に，更に8.82 mN×20×表示テックス数の荷重をかけたときのかせ長 (mm)

b：0.176 mN×20×表示テックス数の荷重をかけたときのかせ長 (mm)

注(12) 水中での浮力を補正した荷重とする。

(13) 20±2 ℃と異なる温度を用いた場合は，その温度を記録に付記する。

(14) 糸の表面のぬれをよくするため，非イオン界面活性剤を2，3滴，水中に混入してもよい。

1

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of   :

Mitsuhiko TANAHASHI, et al.   : Group Art Unit: 3765

Serial No. 09/913,851   : Examiner: Shaun R Hurley

Filed: October 3, 2001

For: HEAT-RESISTANT CRIMPED YARN

DECLARATION UNDER 37 CFR 1.132

Honorable Commissioner of

  Patent and Trademarks

Sir,

1.   I, Takeshi HATANO declare that:

I am one of co-inventors of U. S. Patent Application
Serial No. 09/913,851 filed on October 3, 2001;

I am a citizen of Japan and was born in 24094 Kaminohomura,
Mugi-gun, GIFU, JAPAN in 1947;

I graduated from the Faculty of Spinning and Weaving of
Gifu Technical High School, Japan in March 1965;

I was an employee of Toray Industries, Inc., Japan, from
May 1965 to September 1984, involved in studies of spinning and
weaving research and development of synthetic fibers,
particularly nylon tires and nylon fibers; I have been an
employee of DU PONT-TORAY CO., LTD. since September 1984 and
engaged in developing Kevlar products; I am one of co-inventors
of U.S. Patent Nos. 6,001,474 and 6,348,263 and Japanese Patent
No. 3204773 and other about 70 Japanese patent applications on
synthetic fibers, particularly Kevlar; and the following

experiments were conducted by myself or together with other co-inventors of the above-identified application.

2. Experiments

The invention of U. S. Patent Application Serial No. 09/913,851 filed on October 3, 2001 is described concretely with reference to the following Examples.

The physical properties of the samples produced are measured and evaluated according to the methods mentioned below.

Critical Oxygen Index:

Measured according to JIS K7201 (1999) that indicates a combustion test for polymer materials based on the critical oxygen index of tested samples.

Thermal Decomposition Point:

Measured according to JIS K7120 (1987) that indicates a method for measuring the thermal weight loss of plastics.

Elasticity:

Measured according to JIS L1013 (1999) that indicates a method for testing filament yarn of chemical fibers. According to the Test Method 8.11.A, the elongation percentage in stretch and the stretch modulus of elasticity of each sample are determined.

Fineness:

Measured according to JIS L1013 (1999) that indicates a method for testing filament yarn of chemical fibers. According to the Test Method 8.3, the fineness based on the corrected weight of each sample is determined.

Tensile Strength:

Measured according to JIS L1013 (1999) that indicates a

method for testing filament yarn of chemical fibers. According to the Test Method 8.5.1, the tensile strength of each sample is determined. In order to prevent the monofilaments in each sample tested from being disordered and to ensure uniform stress to all the constituent mono-filaments, the sample is twisted to a twist parameter, K of 1000, before tested.

Snarl Index:

Measured according to JIS L1095 (1999) that indicates a method for testing ordinary spun yarn. According to the Test Method 9.17.2.B, the snarl index of each sample is determined.

Example 1:

Used was polyparaphenylene-terephthalamide fiber filament yarn (Toray-DuPont's Commercial product named Kevlar®) having a critical oxygen index of 29, a thermal decomposition point of 537°C, a tensile strength of 2.03 N/tex, and a tensile modulus of 49.9 N/tex. This is composed of 1000 monofilaments each having a fineness of 0.167 tex, and its fineness is 167 tex. The yarn was first twisted to a twist parameter K of 6308 by the use of a ring twister (Kakigi Seisakusho's conjugated yarn twister, Model KCT), and then heat-set with saturated steam at 180°C for 30 minutes. Next, using the same twister, the yarn was again twisted in the direction opposite to the primary twisting direction to a twist parameter 0, whereby this was untwisted to be crimped yarn of the invention. The physical properties of the crimped yarn were measured.

Examples 2, 3, and Comparative Examples 1, 2:

The same yarn as in Example 1 was twisted, heat-set with saturated steam or through dry heat treatment, and untwisted in the same manner as in Example 1, except that the twist parameter in the primary twisting step was varied as in Table 1. The physical properties of the crimped yarn obtained herein were measured.

In Examples 2 and 3, the twist parameter falls within the preferred range for the invention, while that in Comparative Examples 1 and 2 is lower than the preferred range.

Example 4:

The same yarn as in Example 1 was used herein, except that its fineness is 22.2 tex. The yarn was twisted to a twist parameter K of 5277 in the primary twisting step, then heat-set with saturated steam at 180°C, and then untwisted to be crimped yarn of the invention. The physical properties of the crimped yarn were measured.

The data of the samples in Examples 1 to 4 and Comparative Examples 1 and 2 are shown in Table 1. The relationship between the twist parameter of the yarn not heat-set with saturated steam and the elongation percentage in stretch, one typical characteristic of the crimped yarn is shown in Fig. 1. From the data in Table 1 and Fig. 1, it is understood that the elongation percentage in stretch of the yarn obtained in Examples 1 to 4 is enough for practical use, but that of the yarn obtained in Comparative Examples 1 and 2 is not. This is because the twist parameter of the yarn before heat treatment in the Comparative Examples is low.

Table 1

| | Fineness before treatment (tex) | Count of Twists (/m) | Twist Parameter (K) | Saturated Steam Treatment | | Elongation Percentage in Stretch (%) | Stretch Modulus of Elasticity (%) | Fineness of Crimped Yarn (tex) | Tenacity (N/tex) |
				Temperature (°C)	Time (min)				
Example 1	167	488	6306	180	30	6.6	78.0	170.0	1.14
Example 2	167	639	8258	180	30	11.9	84.5	175.6	0.96
Example 3	167	763	9860	180	30	25.2	50.7	173.3	0.93
Example 4	22.2	1120	5277	180	30	6.5	88.8	23.1	1.21
Comp. Ex. 1	167	260	3360	180	30	2.3	57.8	167.8	1.67
Comp. Ex. 2	167	375	4846	180	30	5.2	71.4	170.0	1.2

Examples 5 to 7, and Comparative Example 3:

Heat-resistant crimped yarn of the invention was obtained in the same manner as in Example 1, except that the twist parameter K in the primary twisting step was 8258 and the time for saturated steam treatment fell between 7.5 and 60 minutes as in Table 2.

In Comparative Example 3, the same yarn as in Examples 5 to 7 was twisted to the same degree without being subjected to saturated steam treatment as therein, then left at room temperature for 1 day and thereafter untwisted. The physical properties of the yarn of this Comparative Example 1 were also measured. The data are all given in Table 2. The relationship between the processing time and the elongation percentage in stretch of the crimped yarn is shown in Fig. 2. From the data of Examples 5 to 7, Example 2 and Comparative Example 3, it is understood that the elongation percentage in stretch of the crimped yarn does not vary so much even when the processing time is longer than 7.5 minutes. This means that the heating time may be short to obtain the heat-resistant crimped yarn of the invention.

Table 2

	Fineness before treatment (tex)	Count of Twists (/m)	Twist Parameter (K)	Saturated Steam Treatment		Elongation Percentage in Stretch (%)	Stretch Modulus of Elasticity (%)	Fineness of Crimped Yarn (tex)	Tenacity (N/tex)
				Temperature (°C)	Time (min)				
Example 5	167	639	8258	180	7.5	16.0	72.1	170.0	0.88
Example 6	167	639	8258	180	15	12.9	79.0	174.4	0.89
Example 7	167	639	8258	180	60	15.8	61.9	170.0	0.74
Example 2	167	639	8258	180	30	11.9	84.5	175.6	0.96
Comp. Ex. 3	167	639	8258	not treated		4.2	52.1	174.4	1.05

Examples 8 to 10, and Comparative Examples 3, 4:

Heat-resistant crimped yarn of the invention was obtained in the same manner as in Example 1, except that the twist parameter K in the primary twisting step was 8258 and the temperature of the steam for heat-setting treatment fell between 130 and 200°C as in Table 3.

In Comparative Example 4, crimped yarn was obtained in the same manner as above except that the temperature of the steam for heat-setting treatment was 120°C. The data are given in Table 3 along with those in Example 2 and Comparative Example 3. The relationship between the processing temperature and the elongation percentage in stretch of the crimped yarn is shown in Fig. 3. From these, it is understood that the temperature of saturated steam for heat-setting treatment is preferably not lower than 130°C for producing practicable crimped yarn.

Table 3

	Fineness before treatment (tex)	Count of Twists (/m)	Twist Parameter (K)	Saturated Steam Treatment Temperature (°C)	Time (min)	Elongation Percentage in Stretch (%)	Stretch Modulus of Elasticity (%)	Fineness of Crimped Yarn (tex)	Tenacity (N/tex)
Example 9	167	639	8258	160	30	9.9	65.2	171.1	0.67
Example 10	167	639	8258	200	30	17.1	62.8	170.0	0.72
Example 2	167	639	8258	180	30	11.9	84.5	175.6	0.96
Example 8	167	639	8258	130	30	6.1	81.3	175.5	1.04
Comp. Ex. 4	167	639	8258	120	30	4.9	55.6	173.4	0.98
Comp. Ex. 3	167	639	8258	not treated		4.2	52.1	174.4	1.05

Examples 11 to 14, and Comparative Examples 5, 6:

The same yarn as in Example 1 was twisted to a twist parameter as in Table 4 by the use of a ring twister, and the twisted yarn was put into a hot air drier and subjected dry heat treatment under the condition shown in Table 4. Next, using the same twister, the yarn was again twisted in the direction opposite to the primary twisting direction to a twist parameter 0, whereby this was untwisted to be heat-resistant crimped yarn of the invention.

In Comparative Example 5, the yarn was processed in the same manner as in Example 11 except that the temperature for the dry heat treatment was 130°C.

In Comparative Example 6, the yarn was processed in the same manner as in Example 12 except that the twist parameter K was 4846.

The data are given in Table 4. The relationship between the processing temperature and the elongation percentage in stretch of the crimped yarn is shown in Fig. 3. Within the range tested, the elongation percentage in stretch of the crimped yarn that had been processed at higher temperatures either through treatment with high-temperature high-pressure steam or through dry heat treatment is higher. Under the condition herein, the elongation percentage in stretch of the crimped yarn processed through high-temperature high-pressure steam treatment is higher than that of the crimped yarn processed through dry heat treatment.

In Comparative Example 5, the elongation percentage in stretch of the crimped yarn obtained is relatively low, since the temperature for the dry heat treatment for the yarn was 130°C

and was low. Accordingly, it is understood that the temperature for the dry heat treatment is preferably not lower than 140°C. In Comparative Example 6, the elongation percentage in stretch of the crimped yarn obtained is also relatively low, since the count of twists in the primary twisting step is small. Accordingly, it is understood that the twist parameter in the primary twisting step is preferably at least 5,000.

Table 4

	Fineness before treatment (tex)	Count of Twists (/m)	Twist Parameter (K)	Dry Heat Treatment Temperature (°C)	Dry Heat Treatment Time (min)	Elongation Percentage in Stretch (%)	Stretch Modulus of Elasticity (%)	Fineness of Crimped Yarn (tex)	Tenacity (N/tex)
Example 11	167	639	8258	200	30	6.9	79.0	171.1	0.96
Example 12	167	639	8258	250	30	12.2	81.6	167.8	0.96
Example 13	167	763	9860	250	30	15.4	45	173.3	0.93
Example 14	167	639	8258	250	7.5	12.8	72.1	170.0	0.88
Comp. Ex. 5	167	639	8258	130	30	5.0	79.8	168.9	0.99
Comp. Ex. 6	167	375	4846	250	30	4.4	76.2	170.0	1.2

Example 15:

The same filament yarn as in Example 1 except that its fineness is 22.2 tex was twisted to a count of twists of 1850/m (this corresponds to a twist parameter K of 8775) by the use of an Italy twister, and 500 g of the thus-twisted yarn was wound up around a flanged aluminum bobbin. In the same manner, prepared were two filament cheeses that had been twisted in opposite directions S, Z respectively, to the same count of twists. These were put into an autoclave for saturated steam treatment, and exposed to saturated steam at 180°C for 30 minutes. After cooled, the yarn was again twisted in the opposite to the primary twisting direction to a twist parameter of 0. Thus untwisted, heat-resistant crimped yarn of the invention was obtained.

The elongation percentage in stretch of the crimped yarn was 17.1 %. The crimped yarn had some residual torque. To cancel their residual torque, the crimped yarns differing in the torque direction of S or Z were paralleled to each other. The paralleled yarn has a total fineness of 88 tex. This was fed into a seamless glove knitting machine, Shima Precision Machinery's SFG-10G Model, and knitted into working gloves of the invention. The cut protection performance of the thus-knitted gloves was measured according to ASTM F1790-97, and was 6.8 N.

On the other hand, paralleled yarn was prepared by paralleling six, commercially-available woolly polyester filament yarns each having a fineness of 16.5 tex (the yarn is from Toray, and this is composed of 48 mono-filaments), for comparison to the heat-resistant crimped yarn of the invention

produced in the above. The paralleled yarn had a total fineness of 99 tex. This was knitted into gloves in the same manner as above, and the cut protection performance of the gloves was measured also in the same manner as above, and was 3.5 N. From the data, it is understood that the cut protection performance of the gloves of the invention is better than that of the comparative gloves.

As being made of the crimped yarn, the working gloves of the invention produced herein fluffs little when compared with those made of spun yarn, Kevlar®. In addition, since they are thin and highly elastic, workers wearing them can handle fine machine parts with ease. Accordingly, the gloves are favorable to, for example, workers who weld electronic parts or who fabricate them in clean rooms, as well as to painters who paint aluminum construction materials, parts of electric and electronic appliances for household use, automobile parts, etc., for ensuring safety work in such production liens and for protecting such workers and painters from being burned and injured by edged tools or parts.

Example 16:

500 g of the same yarn having been twisted under the same condition as in Example 15 was wound up around an aluminum bobbin, and processed in high-temperature high-pressure water at 180°C for 10 minutes. Then, this was cooled, desiccated and dried. Next, this was again twisted in the direction opposite to the primary twisting direction, to a twist parameter 0 by the use of an Italy twister, like in Example 15. Thus untwisted, heat-resistant crimped yarn of the invention was obtained. Its

elongation percentage in stretch was 18 %. As being uniformly heat-set, the crimped yarn was uniform as a whole.

Example 17:

500 g of the same yarn having been twisted under the same condition as in Example 15 was wound up around an aluminum bobbin, and exposed to hot air at 250°C with a hot air drier for 30 minutes. After left cooled in air, this was again twisted in the direction opposite to the primary twisting direction, to a twist parameter 0 by the use of an Italy twister, like in Example 15. Thus untwisted, heat-resistant crimped yarn of the invention was obtained. Its elongation percentage in stretch was 12 %. In this process, however, the heat transmission into the inside area of the yarn layer wound around the bobbin was not enough, and the yarn could not be uniformly heat-set. As a result, the elongation percentage in stretch of the part of the yarn not uniformly heat-set was low, and the yarn was not crimped uniformly. This is not practicable.

However, the problem was solved by reducing the thickness of the yarn layer wound around the bobbin to a half. In that manner, if the yarn layer wound around the bobbin is too thick, the yarn could not be uniformly heat-set in dry heat treatment and the yarn could not be crimped uniformly. Therefore, when the crimped yarn of the invention is produced through dry heat treatment, it is desirable that the yarn layer wound around a bobbin is not too thick.

Example 18:

This Example is to demonstrate continuous production of

heat-resistant crimped yarn of the invention in a false-twisting process. Concretely, a false-twisting unit is disposed in a space between a heating zone having a length of 10 m and an air-cooling zone having a length of 5 m. Yarn is twisted to a count of twists of 1760/m (this corresponds to a twist parameter K of 8258), and introduced into the zone. First, this is heat-set in the heating zone, and then untwisted in the air-cooling zone. The starting yarn is Kevlar® 22 tex of para-aramid fibers. This is the same as the yarn processed in Example 1 except that its fineness is 22 tex. The heating zone was heated at 300°C, and the feed speed of the yarn was 10 m/min. Regarding its physical properties, the heat-resistant crimped yarn produced herein had an elongation percentage in stretch of 12.5 %, a stretch modulus of elasticity of 82.6 %, a fineness of 22.9 tex, and a tenacity of 0.96 N/tex.

Example 19:

The crimped yarn of para-aramid fibers Kevlar® obtained in Example 18 had some residual torque. To cancel their residual torque, the crimped yarns differing in the torque direction of S or Z were paralleled to each other to obtain paralleled yarn. This was fed into a Shima Precision Machinery's 13-gauge seamless glove knitting machine, and knitted into thin gloves. Being different from gloves made of spun yarn, these gloves have the following advantages:

1) They are elastic and well fit worker's hands, and they do not interfere with the movement of worker's hands. Wearing them, workers can do their work with ease.

2) They fluff little, and are therefore favorable to work

in clean rooms where no dust is allowed.

Example 20:

The same filament yarn of polyparaphenylene-terephthalamide fibers (Toray-DuPont's Commercial product named Kevlar®) as in Example 1 was twisted to a count of twists of 640/m (this corresponds to a twist parameter of 8270) by the use of a ring twister, then wound up around an aluminum bobbin, and heat-set through treatment with high-temperature high-pressure steam, and thereafter untwisted to a twist parameter of 0 by the use of the ring twister to be heat-resistant crimped yarn of the invention. The temperature in the high-temperature high-pressure steam treatment was 200°C, and the processing time was 15 minutes.

Examples 21 to 24:

Heat-resistant crimped yarn of the invention was produced in the same manner as in Example 20. In place of the polyparaphenylene-terephthalamide fibers used in Example 20, however, a high-elasticity type of polyparaphenylene-terephthalamide fibers (Toray-DuPont's Commercial product named Kevlar® 49) were used in Example 21; co-paraphenylene-3,4'-oxydiphenylene-terephthalamide fibers (Teijin's Commercial product named Technora®) were in Example 22; holaromatic polyester fibers (Kuraray's Commercial product named Vectran®) were in Example 23; and polybenzobisoxazole fibers (Toyobo's Commercial product named Zylon®) were in Example 24. As in Table 5, the twist parameter of the twisted yarn in these Examples differs from that in Example 20.

Example 25:

Heat-resistant crimped yarn of the invention was produced in the same manner as in Example 20. In this, however, filament yarn having a smaller fineness, 22.2 tex than that in Example 20 was used, and the number of twists per the unit length of the yarn was increased to 1600/m (see Table 5). Accordingly, in this, the yarn was twisted and untwisted by the use of a double twister (this is favorable to twisting yarn to a larger count of twists), being different from that in Example 20 where a ring twister was used.

Example 26:

Heat-resistant crimped yarn of the invention was produced in the same manner as in Example 25. In this, however, yarn of polymetaphenylene-isophthalamide fibers (DuPont's Commercial product named Nomex®) having a fineness of 22.2 tex was used in place of the polyparaphenylene-terephthalamide fibers used in Example 25.

The physical properties of the heat-resistant crimped yarn obtained in Examples 20 to 26 are shown in Table 5. In Table 5, the tensile strength, the tensile modulus, the thermal decomposition point, the critical oxygen index, and the fineness of the starting yarn are all the physical data of the filament yarn not processed into crimped yarn.

From the test data shown in Table 5, it is understood that the elongation percentage in stretch (this indicates the crimp degree) of all the crimped yarns produced in Examples 20 to 26 from different fiber filaments is 8.5 % or more. In particular,

the crimped yarn of para-aramid fibers, polyparaphenylene-terephthalamide fibers and co-polyparaphenylene-3,4'-oxydiphenylene-terephthalamide fibers, that of meta-aramid fibers, polymetaphenylene-isophthalamide fibers, and that of holaromatic polyester fibers had a high elongation percentage in stretch. Above all, the elongation percentage in stretch of the crimped yarn of meta-aramid fibers, polymetaphenylene-isophthalamide fibers was 104.6 %, and it is comparable to the elongation percentage in stretch of ordinary crimped yarn of polyester fibers.

Table 5

Physical Properties (unit)	Chemical Name (trade name is in the lower column)	Example 20 poly-parap henylene-t erephthala mide	Example 21 poly-parap henylene-t erephthala mide (high-elas ticity type)	Example 22 copoly-par aphenylene -3,4'-oxyd iphenylene -terepthal amide	Example 23 holaromati c polyester	Example 24 poly-parap henylene-b enzobisoxa zole	Example 25 poly-parap henylene-t erephthala mide	Example 26 poly-metap henylene-1 sophthalam ide
Physical Properties (unit)		Kevlar®	Kevlar® 49	Technora®	Vectran®	Zylon®	Kevlar®	Nomex®
Tensile Strength	(N/tex)	2.03	1.96	2.47	2.56	3.53	2.03	0.47
Tensile Modulus	(N/tex)	49.9	75	52	59	176.5	49.9	12.4
Thermal Decomposit ion Point	(°C)	537	537	500	400	650	537	500
Critical Oxygen Index		29	29	25	28	56	29	29
Fineness of Starting Yarn	(tex)	167	158	167	167	111	22.2	22.2
Count of Twists	(t/m)	640	640	660	660	780	1600	1600
Twist Parameter		8270	8045	8529	8529	8218	7539	7539
Elongation Percentage in stretch	(%)	28.2	29.7	27.7	22.5	8.5	32.7	104.6
Stretch Modulus of Elasticity	(%)	64.7	46.8	40.1	45.8	56.1	75	97.5
Tenacity of Crimped Yarn	(N/tex)	1.40	1.33	1.66	1.71	2.47	1.42	0.33

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Example 27:

One 22.2 tex filament yarn of polyparaphenylene-terephthalamide fibers (Toray-DuPont's Commercial product named Kevlar®) was fed into a circular knitting machine with 150 knitting needles in total aligned in a circle having a diameter of 91 mm, and knitted into a cylindrical fabric of sheeting (plain stitch fabric). The knitted fabric was exposed to saturated steam at 200°C for 15 minutes. Next, this was left cooled in air, and then unknitted from its last end. Thus unknitted, this gave crimped yarn with its knitted morphology in memory. The elongation percentage in stretch of the crimped yarn was 35 %; and the stretch modulus of elasticity thereof was 56 %.

Example 28:

In the same manner as in Example 27, filament yarn of polymetaphenylene-isophthalamide fibers (DuPont's Commercial product named Nomex®) was knitted into a cylindrical fabric of sheeting (plain stitch fabric). The knitted fabric was heated by a hot air drier at 200°C for 0.5 minutes. Next, this was cooled in air, and then unknitted from its last end. Thus unknitted, this gave crimped yarn. The tensile strength and the lightness of the crimped yarn were measured. Concretely, the yarn was set in a constant-speed tensile tester with its free length between the grips being 200 mm, and tested for its tensile strength, for which the tensile speed was 200 m/min. To measure the lightness of the yarn, used was a Suga Tester's SM color computer.

Examples 29, 30, and Comparative Examples 7, 8:

Crimped yarn was produced in the same manner as in Example 28, except that the knitted fabric was heated at different temperatures as in Table 6. In Examples 29 and 30, the temperature for the heat treatment fell within the preferred range in the invention; but in Comparative Examples 7 and 8, the temperature was higher than the preferred range in the invention.

The test results are shown in Table 6. The relationship between the temperature in dry heat treatment and the tensile strength of the yarn is shown in Fig. 4; and the relationship between the temperature in dry heat treatment and the lightness of the yarn is in Fig. 5. As is obvious from Fig. 4, the tensile strength of the yarn lowered at 350 to 400°C. Also as in Fig. 5, the lightness of the yarn lowered at 350 to 400°C, and the meta-aramid fibers that had been originally white changed into dark brown.

Table 6

	Condition for Heat Treatment		Result in Tensile Test				Data in Colorimetry	Result in Crimped Yarn Test	
	Temperature (°C)	Time (min)	Tenacity (N)	Tenacity (N/tex)	Tenacity Retention (%)	Elongation at break (%)	Lightness (L)	Elongation Percentage in stretch (%)	Stretch Modulus of Elasticity (%)
non-processed	20	-	9.05	0.41	100	17.1	74.5	5.5	92.5
Example 28	250	0.5	-	0.41	100	-	74.5	23.7	91.1
Example 29	300	0.5	9.07	0.41	100.2	17.1	71.1	50	74.8
Example 30	350	0.5	8.71	0.40	96.2	14.7	63	46.2	91.5
Comp. Ex. 7	400	0.5	6.36	0.29	70.3	11	58	52.5	88.3
Comp. Ex. 8	450	0.5	2.22	0.10	24.5	9.0	55	-	-

Fig. 1

Twist Parameter vs
Elongation Percentage in Stretch

Fig. 2:

Processing Time vs
Elongation Percentage in Stretch

Fig. 3

Processing Temperature vs Elongation Percentage in Stretch
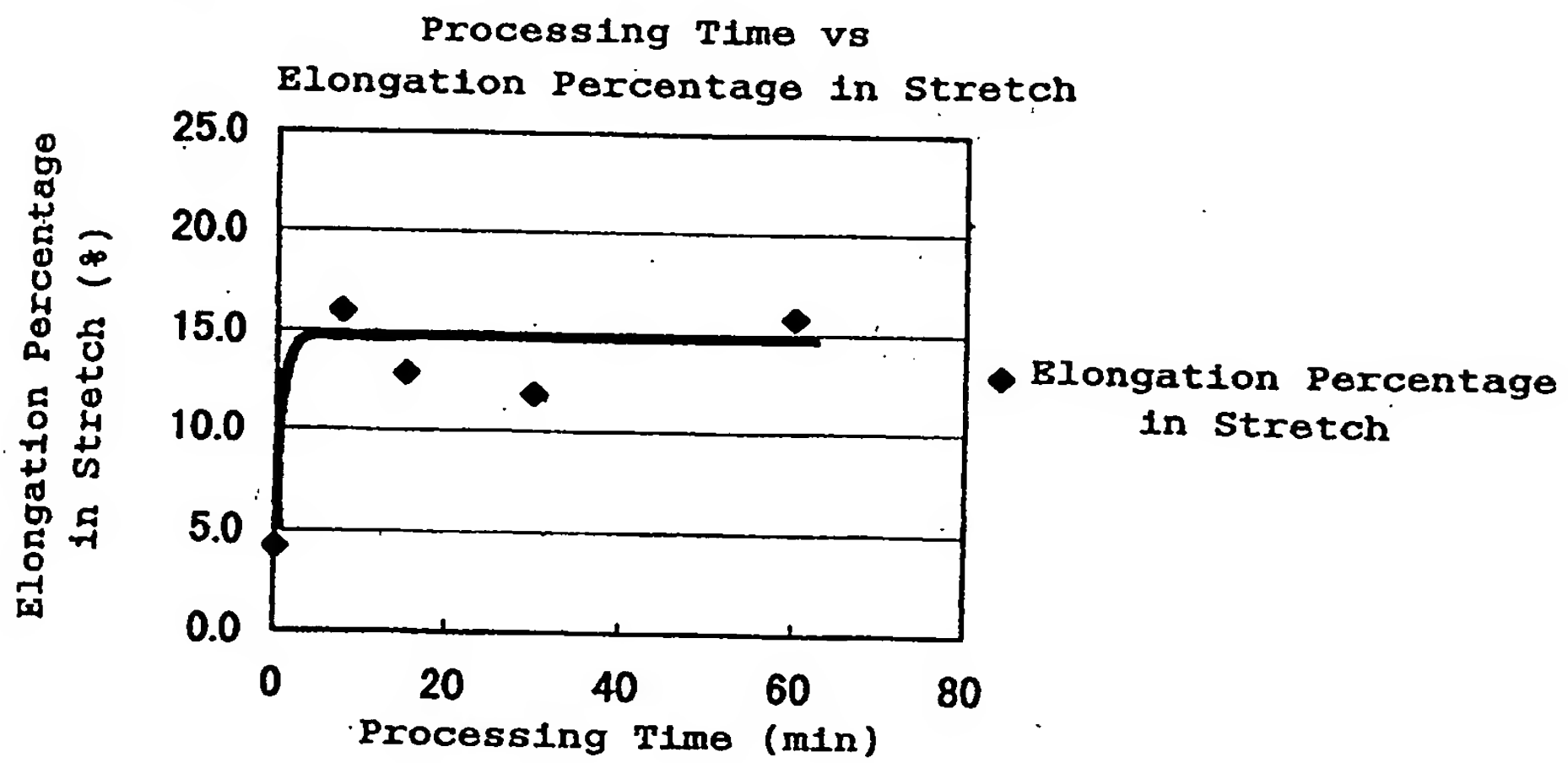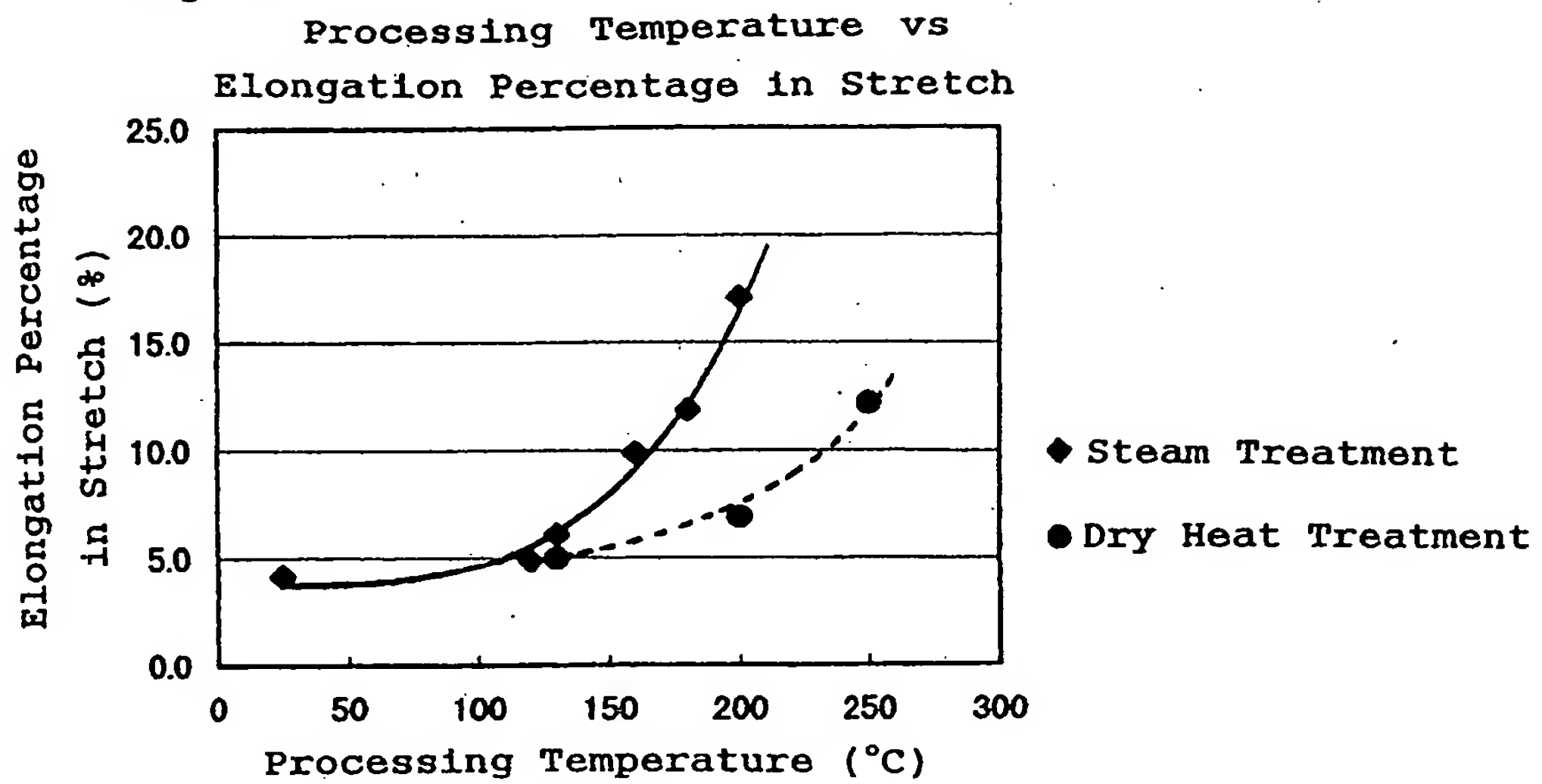

♦ Steam Treatment

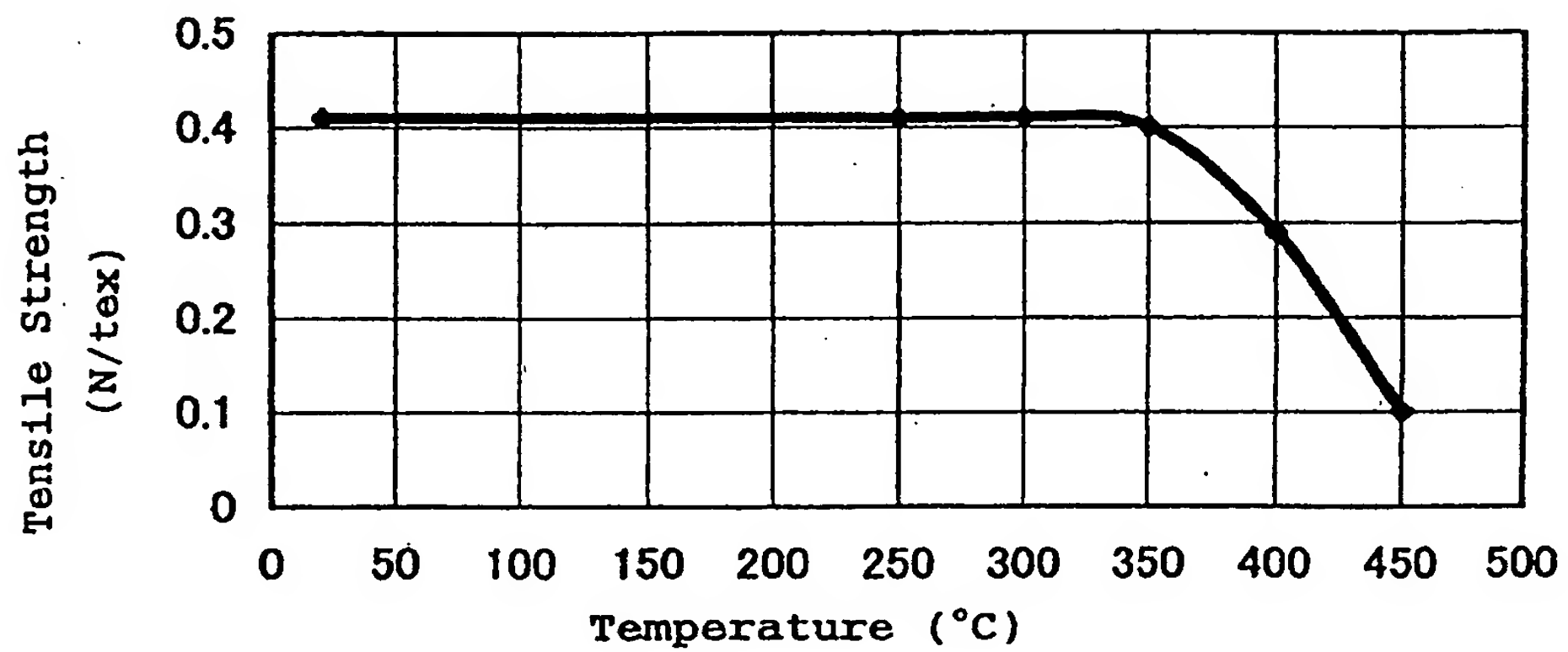● Dry Heat Treatment
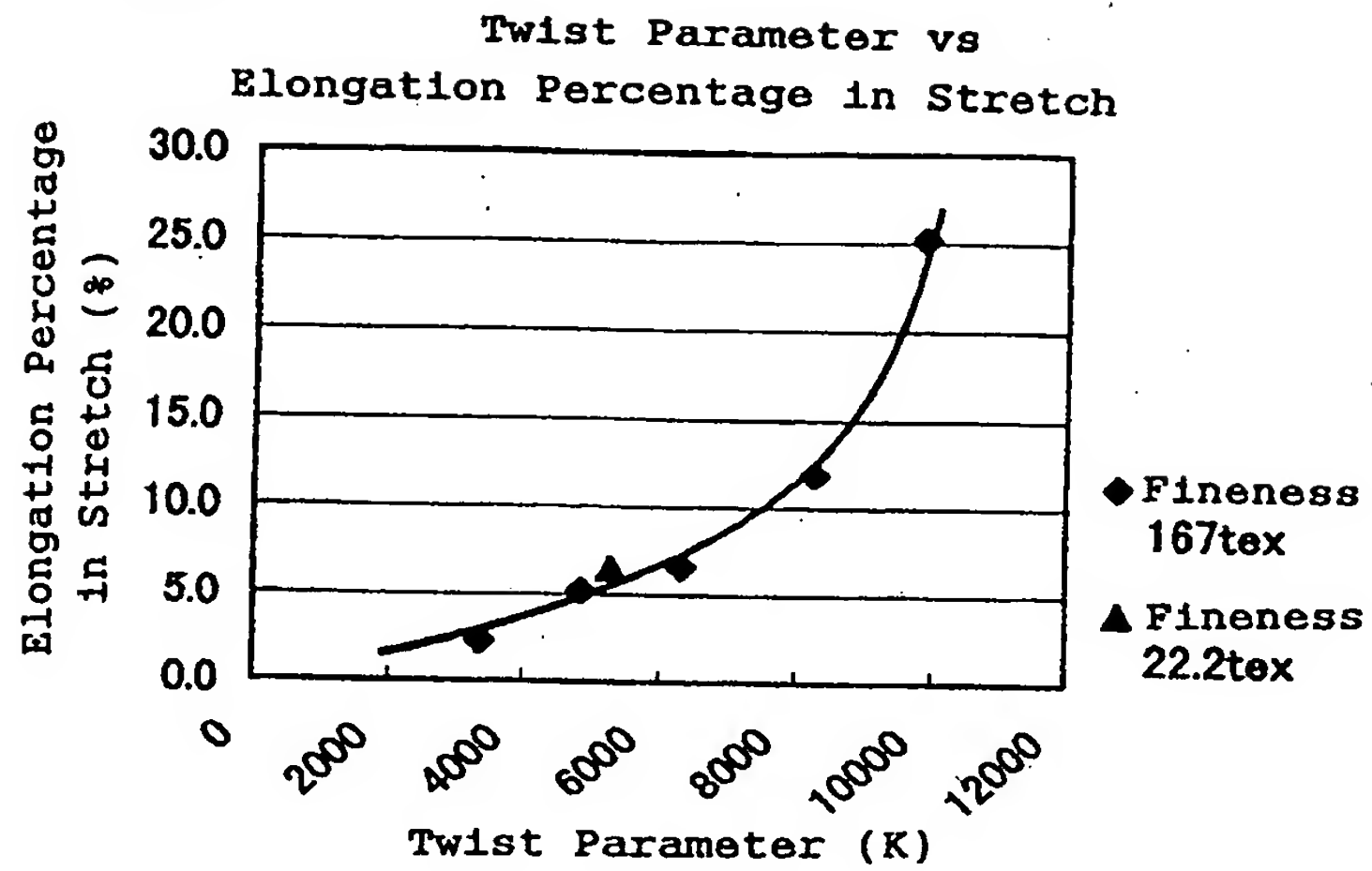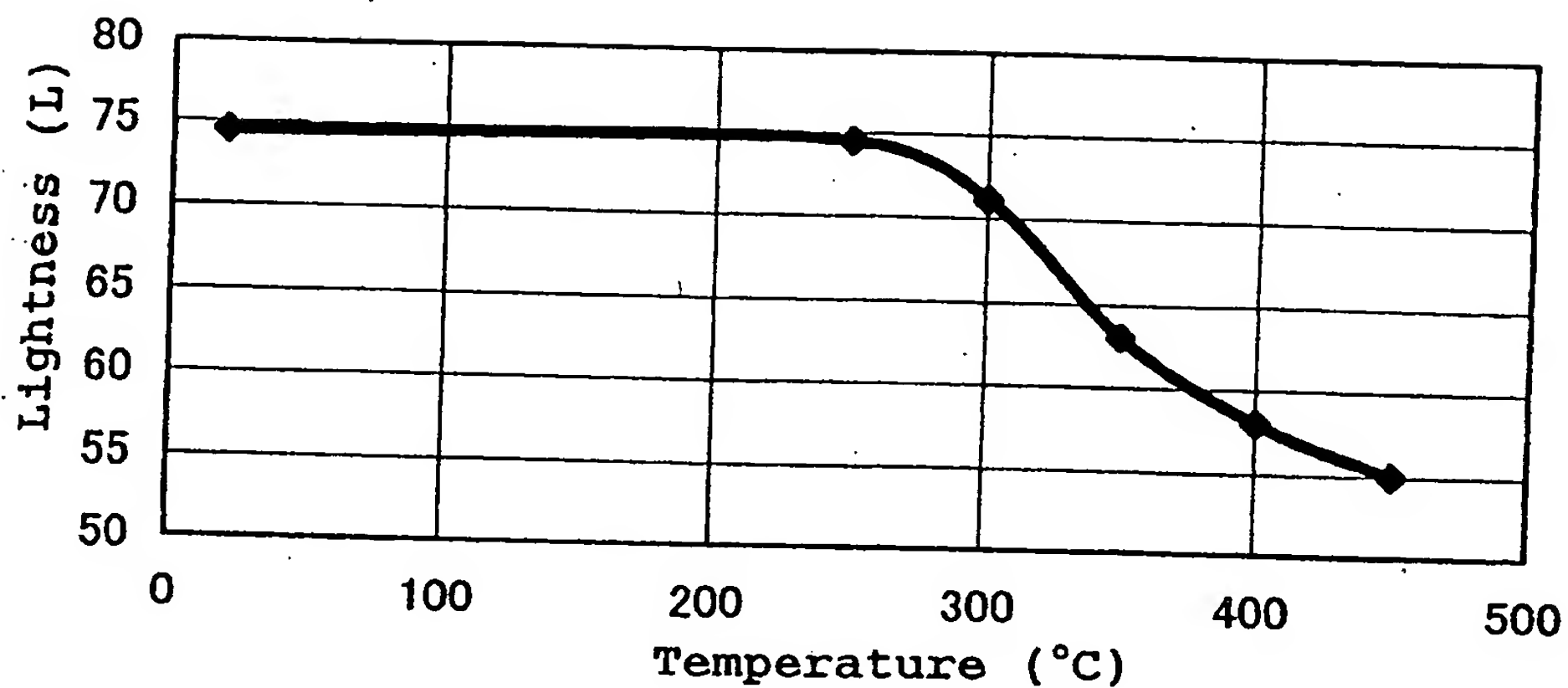
Fig. 4

Fig. 5

3.   It is declared by the undersigned that all statements made herein of undersigned's own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001, and that such willful false statements may jeopardize the validity of this application or any patent issuing thereon.

This   30th day of April   , 2003

Takeshi Hatano
_____

Takeshi HATANO